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Abstract

Populations of both Gambel's and scaled quail surveyed in southern Arizona declined by 60% from October 1975 to June 1976. Masked bobwhite population density increased during the study because of additional releases, but survival patterns are uncertain. Raptors were efficient quail predators.

Gambel's quail were associated with a dense overstory of mesquite, hackberry, wolfberry, and catclaw. Understory species varied in density and appeared less essential to good habitat. Scaled quail preferred open, grass-shrub habitat, with few of the plants over 6 feet tall. Masked bobwhite selected dense, grass-weed habitat, with pigweed a characteristic species.

Green vegetation and insects were seasonally important as moisture sources. Free water was not necessary for these quail part of the year.

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The masked bobwhite quail (*Colinus virginianus ridgwayi*) was a resident of the mesquite-grassland habitat in southern Arizona and northern Sonora, Mexico in the 1800s (Tomlinson 1972). Late in the 19th century, extreme overgrazing and severe drought denuded the range. The masked bobwhite had disappeared from Arizona by 1900.

Between 1968 and 1970, 57 masked bobwhites were captured in Sonora, Mexico by the U.S. Fish and Wildlife Service and were sent to the Patuxent Wildlife Research Center for propagation. Offspring now are being released in southern Arizona to try to reestablish this bird. For this reintroduction program to succeed, the bobwhite must adapt to present range conditions and possible competition with native Gambel's quail (*Lophortyx gambelii*) and scaled quail (*Callipepla squamata*).

Objectives

This study was designed to provide data on the following objectives:

1. To compare and classify specific plants and plant formations selected for cover by each of the three quail. (Cover is vegetation used as protection from weather, predators, and man, and for roosting, nesting, loafing, raising of broods, and other life functions.)

2. To compare and quantify use of open water and of foods containing water by the three quail species.

3. To compare attrition rate among the three quail species, and identify causes of loss to avian and mammalian predators, weather, and other decimating factors.

Description of Study Area

The study was conducted on parts of the Otis Carney ranch, in the Altar Valley, 72 kilometers southwest of Tucson. The site, leased by the USDI Fish and Wildlife Service, is located within historic masked bobwhite range. It was selected because it resembles habitat in Sonora where the bird is now resident.

The area lies on a gently sloping bajada at elevations from 1,060 to 1,130 meters. Characteristic vegetation includes mesquite (*Prosopis juliflora*), hackberry (*Celtis reticulata*), wolfberry (*Lycium* spp.), falsemesquite (*Calliandra* spp.), snakeweed (*Gutierrezia* spp.), grama grasses (*Bouteloua* spp.), and lovegrasses (*Eragrostis* spp.). Surface soils are gravelly sandy loam or loam underlaid by clay loam and clays. Annual precipitation averages 30-40 centimeters, with 60% falling between June and October.

Methods

Field work began in February 1975 and ended in July 1976. Gambel's and scaled quail were captured in Stoddard, funnel-type, wire traps baited with grain, or in cock and hen traps using previously trapped birds as decoys. Captured birds were banded with sequentially numbered aluminum leg bands, and some were marked with plastic back tags to aid field identification.

Known numbers of different age classes of masked bobwhites were released. Chicks were adopted to Bantam hens, vasectomized Texas bobwhite quail (*Colinus virginianus texanum*), scaled quail, Gambel's quail, and masked bobwhite quail, and were released as a brood in the field with the foster parent or parents. Subadult

and adult masked bobwhites were given training in "call boxes" to acclimate them to the area and then were released. Chicks are defined as birds less than 4 weeks old, subadults as birds from 4 to 12 weeks old, and adults as birds older than 12 weeks.

Quail populations were determined by trap-retrap formula (Lagler 1950 *in* Gallizioli 1955) and observations of covey numbers and movements, including movements of color-marked individuals. Attrition was estimated from seasonal changes in quail populations. Fecal droppings of mammalian predators were collected periodically and examined to determine mammalian impact on quail population density. Seasonal changes in raptor population density also were noted. Attempts were made to classify quail kills by raptors, mammals, or other causes. Field observations provided information on other decimating factors.

Extensive field observations and limited telemetry data were used to determine cover requirements. Solar or battery-powered transmitters weighing 9 to 13 grams were attached to Gambel's, scaled, and bobwhite quail. Their movements were monitored with a portable receiver and directional antenna.

Once areas of high quail use were identified, key plant species were quantified. Mesquite, hackberry, wolfberry, catclaw (*Acacia* spp.) and falsemesquite were counted on a 0.4-hectare plot at each site. Burroweed (*Haplopappus* spp.) and snakeweed were counted in the NE and SW quarters of each plot. A visual estimate (to approximate the nearest 10%) of the amount of ground shaded by the crown of each plant species formation further quantified cover density. Known roost trees of Gambel's quail were described by species and height.

Important foods and feeding cover used by each quail species were identified by field observation and by a limited crop analysis.

The importance of free-standing water and foods containing water was determined by field observations and by time-lapse photography at water holes.

Results and Discussion

Cover Requirements of Gambel's Quail

Trapping data from 186 Gambel's quail captured 745 times and more than 300 field observations showed Gambel's quail were tied closely to the mesquite, wolfberry, hackberry, and falsemesquite habitat type found along sandy washes and around stock tanks (fig. 1). Five areas intensively used by Gambel's quail were identified, and vegetation on a 0.4-hectare plot at each site was quantified (table 1). Average density per plot of key plants were 62 catclaw, 58 mesquite, 75 hackberry, and 60 wolfberry. From 60 to 80% of these were taller than 2 meters. This overstory cover shaded from 50 to 75% of the ground. Understory density averaged 107 snakeweed and 10 burroweed per plot (table 1). Grass cover varied from 50% ground cover in ungrazed areas to nearly zero on grazed sites. Several ungrazed areas with high quail density were grazed later with no apparent change in occupancy. Dense understory cover did not appear to be important for Gambel's quail habitat.

Figure 1.—Gambel's quail habitat was characterized by dense stands of mature mesquite, hackberry, wolfberry, and falsemesquite along sandy washes and around stock tanks.

Table 1.—Density (plants per 0.4 hectare) of key plant species in quail habitat.

Site	Catclaw		Mesquite		Hackberry		Wolfberry		Snakeweed		Burroweed	
	Gambel's	Scaled	Gambel's	Scaled	Gambel's	Scaled	Gambel's	Scaled	Gambel's	Scaled	Gambel's	Scaled
A	25	0	49	42	61	0	59	32	60	482	4	132
B	139	0	73	33	118	0	11	160	172	228	10	48
C	65	0	42	21	93	3	13	67	84	294	2	88
D	23	0	58	18	24	1	145	44	144	346	22	56
E	57	0	70	28	80	0	72	111	76	246	14	108
Mean	61.8	0	58.4	28.4	75.2	0.8	60.0	82.8	107.2	319.2	10.4	86.4

Of 87 roost sites used by Gambel's quail, 52 were in hackberry, 11 in catclaw, 10 in wolfberry, 8 in mesquite, 5 in jojoba (*Simmondsia* spp.), and 1 in a paloverde (*Cercidium* spp.). Seventy five of these were from 2 to 5 meters above the ground, with the rest located higher in the trees. Bushes or trees with dense foliage, branching, and thorns characterized ideal roost sites. Perhaps these best protected quail from avian or mammalian predators. Sites were high enough to give protection from ground predators but low enough to minimize exposure to weather.

Availability of suitable roost sites may significantly limit Gambel's quail distribution. Approximately 60 hectares of the study area, characterized by a continuous mesquite bosque, never supported more than a few quail. The area was adjacent to good Gambel's quail populations, and appeared similar in tree density and height to the good habitat. The only apparent difference was that the mesquite bosque contained very few shrubs with dense foliage and branching for roosts.

The favorable growth form, comprised of mature mesquite, hackberry, wolfberry, and catclaw, provided cover for all life functions of the resident Gambel's. Birds were observed feeding, loafing, roosting, and raising broods. Of three nests found, two were under thorn apple shrubs (*Datura* spp.) and one under a catclaw; all three were adjacent to the growth form described above.

Gambel's quail stayed close to their preferred habitat. Approximately 90% of the quail observed were in the mesquite-hackberry growth form. Few Gambel's were seen more than 50 to 100 meters from dense cover. When caught in the open, they immediately ran or flew to the nearest mesquite-hackberry cover. The "edge" effect of the mature mesquite bordering open grasslands created a distinct boundary for Gambel's movement instead of providing a favorable juxtaposition as has been found for bobwhite (Errington 1941, Kabot and Thompson 1963, Klimstra and Roseberry 1975).

Gambel's coveys maintained well-defined home ranges within their preferred habitat from September to December. Observed coveys had a home range of 4 to 16 hectares in March 1975. Gullion (1962) found an average home range of 14 hectares for 10 coveys in Nevada.

From late December through February, approximately two-thirds of the Gambel's quail moved out of the study area. A search of surrounding habitat showed high numbers of quail in the Baboquivari mountain foothills, about 5 kilometers west. Quail in these canyons remained in the mesquite-hackberry habitat along the washes. Two Gambel's quail marked with backtags were seen in winter at the Elkhorn Guest Ranch, about 8 kilometers west of where they were banded the previous summer. The reason for this movement is unknown. The movements began when nightly temperatures dropped near freezing. Possibly cold air drainage from the mountains onto the bajada produced a more favorable temperature range at higher elevations.

Large numbers of quail returned to the study area in March. One of the quail observed at the Elkhorn Ranch was recaptured within 50 meters of where it was banded.

Coveys began to disperse for breeding in late March. By mid-April, most birds were in groups of four to six, and by early May, almost all were paired. This period showed maximum distribution of Gambel's (on the study area), with pairs scattered throughout all suitable habitat.

Cover Requirements of Scaled Quail

Scaled quail and Gambel's quail habitat were mutually exclusive. While Gambel's quail occupied the dense vegetation along washes, the scaled quail were found in the intervening grass-shrub habitat. Key areas for scaled quail were identified from 91 captures of 43 individuals and more than 100 field observations. Vegetation analysis at five 0.4-hectare plots showed an average of 28 mesquite, 1 hackberry, 83 wolfberry, 319 snakeweed, and 86 burroweed (table 1). Of the mesquite, hackberry, and wolfberry, only two plants per plot were taller than 2 meters. Grass density varied from 5 to 40% ground cover. Good scaled quail habitat was characterized by a growth form of low-growing grasses, forbs, and shrubs, with an overall ground cover between 10 and 50% (fig. 2).

Scaled quail normally used grass clumps and shrubs for cover while feeding but frequently were seen crossing 25 to 50 meters of bare ground with no apparent concern. When disturbed by humans or mammalian predators, the birds generally hid in snakeweed or grass. If approached, they would fly 100 meters or more and

Figure 2.—Typical scaled quail habitat contained sparse grass-forb cover and scattered shrubs and trees less than 2 meters tall.

then either run from sight or again seek cover in the grass or snakeweed. When a hawk soared nearby, quail hid under wolfberry or in dense snakeweed until the hawk left. Quail preferred wolfberry and mesquite from 0.5 to 1.5 meters tall for loafing cover. These plants provided midday shade but were open around the base to allow easy escape from predators.

Only two scaled quail nests were found—one in a grass clump in open grass-shrub habitat, and the other in loose hay near the field station. Eggs in the first nest were replaced with 15 masked bobwhite eggs, of which 10 hatched. The second nest was abandoned.

Two male scaled quail were fitted with transmitters between June and October 1975 to monitor their movements. One bird provided 2 weeks of continuous data before a predator killed it. The second was found 15 times during a 40-day period before the signal was lost. Both had home ranges (21 and 24 hectares) characterized by low-growing grasses, snakeweed, and wolfberry, generally bounded by mesquite-lined washes earlier described as Gambel's habitat.

Scaled quail usually avoided two habitat types: tall, dense growth favored by Gambel's, and the lovegrass-grama grass flats at the southern edge of the study area. These dense grass flats may have limited the birds' vision, making them more vulnerable to predators.

Seasonal movements of scaled quail were similar to that of Gambel's quail. From September to November, the birds maintained relatively stable territories, but between mid-November and early March, 75 to 90% of the population moved off the study area. Correspondingly high populations were found then in the Baboquivari mountain foothills. In mid-November 1975, a back-tagged quail was seen with a large covey 3 miles west of the study area. Scaled quail habitat selection in the mountains was consistent with that found on the study area—mixed grasses and shrubs with few plants over 2 meters tall.

Quail population density increased again in March, with most birds in groups of four to eight. Pairing and maximum dispersal was complete by mid-June. Nesting probably did not begin until early July.

Cover Requirements of Masked Bobwhites

Release techniques for masked bobwhite quail used before fall of 1975 generally were unsuccessful. Few birds were seen more than 1 week after their release. Therefore, data on habitat preference were limited. Techniques for training pen-raised quail to survive in the wild were refined during the winter of 1975-76. Consequently, observations during spring and summer were sufficient to begin to identify preferred habitat.

Four masked bobwhites (3 female, 1 male) were captured October 25, 1975, along the east boundary of the study area. These birds had been released as subadults about 2 months earlier with limited call box training. Lovegrasses and grama characterized the release site. The capture site (2.5 kilometers NE of release area) had a dense understory vegetation of pigweed and careless weed (*Amaranthus* spp.) with an overstory of mature mesquite, paloverde and wolfberry. The male was fitted with a transmitter, and all four birds were released. The next day there was no signal from the transmitter. Evidence was found that a hawk had killed a bobwhite. The three females were recaptured in the same pigweed patch November 5 and 11, but the male was not seen again.

A male Texas bobwhite (released during the summer as a foster parent for masked bobwhite chicks) was captured December 4, 1975, in another pigweed patch near the center of the study area. This bird was fitted with a transmitter and returned to its capture site. From December 5 until December 15, when the signal was lost, the bird's location was determined daily at dawn, midday, and dusk. A female masked bobwhite accompanied the Texas bobwhite during this period. Each of these birds was located within 0.5 hectare of pigweed surrounded by mature mesquite, hackberry, and wolfberry.

A second male Texas bobwhite was fitted with a transmitter December 19, and was released at the centrally located pigweed patch along with four masked bobwhites. These birds remained together in the pigweed patch for 2 days before the transmittered bird returned to the quail pens alone.

Approximately 200 bobwhites received call box training between March and June 1976, at six sites on the study area and in four sites on the Buenos Aires Ranch 40 km south of the Carney Ranch. Release sites were chosen for availability of forb-grass cover, proximity of brushpiles or mesquite overstory for cover, and presence of winter annuals.

These bobwhites quickly learned to use brushpiles, mesquite thickets, and dense grass-shrub "pockets" for cover. When flushed from this cover, many birds flew into nearby trees and perched 5 to 10 meters above the ground. Other times, bobwhites flew 100 to 500 meters out into lovegrass flats to find escape cover.

Generally, the birds appeared capable of using any habitat on the study area but preferred the "edge" effect of the mesquite-lined washes adjoining open, grass-forb sites. Certainly, some site selection was predetermined by field personnel choice of the call box locations, but the extent of this bias cannot be evaluated fully.

Tomlinson (1972) found that bobwhites in Mexico preferred a juxtaposition of dense forb growth, dense grasses, and brush or trees. Bobwhites moved to more woody thickets in winter. Gallizioli (1964) noted that pigweed was an abundant forb in bobwhite habitat in Sonora.

The Carneys began sprinkler irrigation of a circular 53-hectare pasture adjacent to the NE edge of the study area in May 1976. By June, this field had lush stands of lovegrass, pigweed, panic grasses (*Panicum* spp.), and many other grass and forb species. Single males and paired bobwhites were observed consistently throughout June and July in this pasture. The males began "bobwhite" calling in mid-July. Observations indicated at least four males established territories.

Although the situation was artificial, this field probably represented the best bobwhite habitat available nearby. Dense vegetation (75-100% ground cover), excellent plant diversity, high humidity from retention of precipitation and evapotranspiration, and abundant insect life should have made this area ideal for bobwhite reproduction. Gee (U.S. Fish and Wildlife Service, 1976, personal communication) found that high humidity is important in stimulating reproduction in masked bobwhite quail.

These observations indicate that pen-raised masked bobwhite quail can survive in present southern Arizona habitats. From October to June, bobwhites preferred weedy areas with nearby tree-shrub overstory. This habitat type is intermediate between the open habitat selected by scaled quail and the more dense vegetation selected by Gambel's quail (fig. 3). Where dense forb areas are limited or absent, bobwhites overlapped heavily on Gambel's quail habitat.

Figure 3.—Masked bobwhite quail selected habitat characterized by dense grass-weed growth.

Adequate breeding habitat for bobwhites probably is the key factor that will determine the success of the masked bobwhite reintroduction program. If high humidity is critical for breeding, then ungrazed areas of dense grasses and forbs must be maintained where evapotranspiration can produce a humid microclimate.

Quail Population Density and Attrition

Gambel's quail were the most abundant on the study area. Extensive trapping in October and again in March allowed good population estimates. Observations throughout the year showed major trends. Approximately 175 resident Gambel's quail were in or immediately adjacent to the study area during October. Winter movements into the Baboquivari mountains reduced the resident population to about 60. The spring return of resident and unmarked transient birds raised the

bird population density back to the fall level, but pairing of birds in April-May dispersed the transients. The resulting breeding population of about 70 birds represents 40% survival of the fall population.

Scaled quail were not abundant on the study area during 1975-76. The fall population of about 75 birds decreased to about 10 in the winter when most moved into the mountains. About 40 quail, mostly birds banded in the fall, plus a few unmarked birds, returned in spring. Approximately 30 scaled quail (40% of the fall population) made up the summer breeding stock.

Masked bobwhite releases in 1975 included 385 chicks adopted to foster parents, 107 subadults, about 124 adults, and 10 bobwhite eggs hatched by a scaled quail (Ellis, U.S. Fish and Wildlife Service, 1976, personal communication). Fall trapping and censusing with trained bird dogs accounted for only 11 bobwhites. However, information from previous years shows high potential for bobwhite dispersal. A male masked bobwhite drowned in a swimming pool June 19, 1974, about 9 kilometers NNE from its release site the previous July. At least two other bobwhites were seen at the drowning site as late as November 1974 (Ellis, U.S. Fish and Wildlife Service, 1976, personal communication).

Approximately 80 bobwhites were released from March to June 1976 after call box training. No intensive followup trapping was done to determine their survival rate, but in June, three of these birds were recaptured in the irrigated field described earlier. Two pairs were seen in July in the irrigated field, and at least five calling males had established territories.

Potential quail predators on the study area include a long list of mammals, birds, reptiles, and insects. Fecal samples from mammalian species indicated that they were not efficient quail predators. Bird remains were found in 2 of 18 bobcat (*Lynx rufus*) droppings; unidentified feathers were present in 6 of 78 coyote (*Canis latrans*) droppings; and no bird remains were found in 8 fox (*Urocyon cinereoargenteus*) samples. One scaled quail (carrying a transmitter) was believed to have been killed by a mammal. The stomach of a coyote, killed June 26, 1974, a few hours after subadult bobwhites had been released nearby, contained two of those birds.

Avian predators apparently were responsible for most quail kills. Neatly clipped feathers, presence of avian "whitewash," or location of feathers under "butcher block" trees indicated that 19 Gambel's, 16 scaled, and 2 bobwhite quail were killed by raptors. Thirty-three of these kills were found between September and December during the fall hawk migration.

Cooper's hawks (*Accipiter cooperii*) and sharp-shinned hawks (*Accipiter striatus*) were frequently seen perched or flying in the habitat preferred by Gambel's quail, and probably accounted for much of the Gambel's mortality. Marsh hawks (*Circus cyaneus*) normally soared low over the more open scaled quail habitat, and consequently may have been efficient predators on this quail species. Other raptors frequently seen on the study area were red-tailed hawks (*Buteo jamaicensis*), kestrels (*Falco sparverius*), prairie falcons (*Falco mexicanus*), and great horned owls (*Bubo virginianus*).

Two bobwhite chicks were killed by shrikes (*Lanius ludovicianus*), and one bobwhite subadult was killed by a roadrunner (*Geococcyx californianus*). However, neither of these predators was suspected of consistently feeding upon quail. No other decimating factors could be clearly defined.

Use of Open Water

Gambel's quail were often seen near water because their habitat surrounded all three sources of water on the study area. In contrast, scaled quail were seen less frequently near water because their habitat seldom was within 200 meters of water. From September to March, Gambel's quail were seen almost daily within 25 meters of open water. However, they were seen drinking only about once a week. During the same period, scaled quail were seen at stock tanks usually once every 10 to 14 days, but most sightings included at least one bird drinking.

Gambel's quail often were seen at tanks during the dry period of April-June. Scaled quail also were seen there more often, every 2 to 3 days. Both species were seen drinking during most of these observations.

Twenty-three days of time-lapse photography at stock tanks between December and February, and 10 days coverage in early June, provided data similar to the field observations. Quail frequently fed near the water in winter, but few went to the water's edge. Most birds went directly to the water to drink in June and then either fed nearby

or left the area. Poor film quality prevented positive species identification.

Bobwhites were seen once in December at a stock tank, and were consistently seen drinking on irrigated land in May and June.

Open water was considered unnecessary for all three quail species from September to March, but more birds were observed drinking during the drier months. Open water probably was most attractive to bobwhites and least attractive to scaled quail.

Interspecific Aggression

Gambel's and scaled quail were frequently seen together in the fall and winter with no apparent aggression displayed by either species. When quail paired up in spring, intraspecific aggression was seen among Gambel's males and, to a lesser extent, among scaled quail males, but never between species.

A unique situation was observed June 24, 1976, at a small brush pile near the quail pens. One pair of bobwhites, two pairs of scaled quail, and two pairs of Gambel's (one pair with nine chicks) were all using the same brush pile for loafing cover with no sign of interspecific aggression. Subsequently, combinations of the three species were frequently seen at the same brush pile with no social problems.

Habitat Management for Masked Bobwhite

The masked bobwhite quail appears to need a niche intermediate between that of the Gambel's and scaled quail. Good bobwhite habitat appears to require a dense growth of grasses and weeds with species diversity. General guidelines for improving or creating masked bobwhite habitat should include the following: 1) select sites with naturally dense grass-weed vegetation, 2) irrigate, where feasible, to stimulate growth and to increase plant species diversity, and 3) eliminate or control livestock grazing to improve range conditions and ground cover density.

Summary

Gambel's quail habitat included a dense overstory cover of mesquite, hackberry, wolfberry, and catclaw with an understory of snakeweed and burroweed. Grass cover did not appear necessary for good habitat. Most feeding, loafing, roosting, and nesting was confined to this habitat type. Roost sites normally were 2 to 5 meters above ground in bushes with dense foliage and branching. Availability of suitable roost sites may limit distribution of Gambel's quail.

Scaled quail preferred low grasses and shrubs with 10 to 50% ground cover. Low bushes provided loafing and feeding cover, and denser grass or shrubs were used for escape cover.

Both Gambel's and scaled quail moved into the foothills during the coldest period of the year, but returned to the study area when temperatures increased.

Masked bobwhites preferred habitat with dense ground cover and good diversity of food and grass species. Where this type was limited, they moved into Gambel's habitat. High humidity is believed necessary for bobwhite reproduction; therefore, the presence of dense vegetation to provide the right microhabitat may determine breeding success.

Gambel's quail population density was roughly twice that of scaled quail. Decimating factors reduced both populations by 60% between October and June. Mammals were not efficient quail predators, but raptors took a significant portion of the quail population.

Green vegetation and insects became important seasonally as sources of moisture. Use of open water by quail was not necessary until the driest months but then may have become limiting to quail survival.

Interspecific aggression did not appear to be a problem among the three quail species.

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